Web-Based Collaboration Technology for the Delivery of Health Care

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Despite the advent of the World Wide Web and near instantaneous access to a wide range of information from diverse sources, we still face a number of challenges in enabling authorized health care providers to access their patients' distributed electronic medical records.

But we have made progress. Not too long ago, it was fairly common to have to use multiple computers to access different departmental information systems, each with its own access control accounts and passwords and its own application program and database, requiring one to type the same information over and over.

The Web has helped overcome some of these problems. The universal client application (the browser) intelligently interprets and presents metatagged information, enabling access to a variety of information sources and services.

At West Virginia University, we were one of the first to implement a Web-based distributed multimedia medical record[1], enabling health care providers to collaborate to improve health care delivery. *A*dvanced *R*esearch *Te*stbed for *M*edical *I*nformatics (ARTEMIS) is an open-architecture implementation of collaboration technology in the health care arena that utilized information-sharing, team coordination, and computer-supported conferencing facilities. We present herein the results of our research during the period 1993 to 1996.

Initial versions of the ARTEMIS system were implemented in 1993 as part of a project funded in part by the National Library of Medicine as well as the U.S. Department of Defense's Defense Advanced Research Projects Agency.

The architecture of the ARTEMIS system was organized as a set of three layers: (1) role-based clients, (2) middleware to support health care transactions, and (3) an information source layer. In addition, the ARTEMIS system utilized desktop videoconferencing to enable spontaneous teleconsultations as well as asynchronous e-mail-based correspondence among health care providers.
We modified the source code for the original Web browser (Mosaic version 2.3 from the University of Illinois' National Center for Supercomputing Applications) to create a unique health care application that supported facilities such as multiple documents (e.g., frames), enhanced security (e.g., cache, history, and navigation management), and e-mail-based referrals. Health care providers could use the browser to dictate notes and submit them via the Internet for archival and transcription. The dictated recording could be accessed along with the rest of the patient's Web-based chart until the physician signed off on the transcription—a feature absent even in many of today's systems.

We created Web*[2], a CGI scripting engine enabling us to create Tool Command Language (TCL)-based scripts for dynamic Web pages (such as patient charts), context-sensitive flows, and role-based views. These scripts—called layout pages—were created for each type of Web page. Via extensions to HTML, the layout pages could communicate metainformation to the ARTEMIS browser. We also developed TCLDII to

allow scripts to access CORBA-based middleware.

CORBA-based open, interoperable component technologies enable implementation of middleware to integrate information from diverse systems. Such middleware enables:

- Role- and context-based access to multimedia patient charts
- Incorporation of workflow
- Integration of application user interfaces and system interfaces and protocols such as HL7 messages

The ARTEMIS system was implemented in a couple of clinics (Valley Health Systems, Inc.) and two hospitals (St. Mary's Hospital and Cabell-Huntington Hospital) located in and around Huntington, WV. In the pilot site trials, our objective was to assess the effect of computer-supported collaboration facilities on quality of care and access to care. Valley Health physicians had admitting privileges at the hospitals, and their patients are occasionally sent for diagnostic tests or admitted for treatment to those hospitals. Since Valley Health clinics primarily used paper-based medical records, we implemented an Oracle-based medical repository, which contained dictations, transcribed progress notes, and other elements of the charts of selected patients participating in the trials. An HL7 messaging interface via CORBA allowed certain patient record elements from the hospital tobe available through ARTEMIS. An x-ray film scanner at one of the hospitals allowed the image to be made available at the clinic for nondiagnostic purposes, such as review and patient education. A physician at any of the clinics could then access his or her patient's distributed multimedia medical information via the ARTEMIS browser for review, update, dictation, signoff, or referral purposes.

Our evaluation of the ARTEMIS system showed that it was well received by the health care provider community in our pilot sites. Its user interface was intuitive and easy to use. It was demonstrated at technical conferences[3] and has received significant print and television news media coverage. The lessons learned from this experiment[4] include:

- The system's response time must be very fast—comparable to that of a paper-based chart.
- Data entry using the keyboard is not an acceptable data input mechanism.
- Synchronous consults were not used due to health care provider scheduling conflicts. Store-forward, asynchronous communications is the favored mode of communications and is useful in overcoming the isolation of rural health care providers.
- Electronic medical records can reduce the problem of "missing information" caused by misplaced files or delayed filing of medical records.
- Turnaround time was reduced for dictations to be transcribed and sent to the physician. ARTEMIS dictated recordings were available even while the report was being transcribed.

The ease of access of integrated medical records via the Web, however, raises concerns about the security policies and practices of health care organizations and their measures to ensure the confidentiality and privacy of electronic health information[5]. Many research efforts have been investigating this critically important issue.
A companion paper at this conference discusses our research involving security measures based on public key cryptography in secure telemedicine applications.

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